(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 324 423 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
02.07.2003 Bulletin 2003/27

(21) Application number: 01130864.0

(22) Date of filing: 27.12.2001

(51) Int Cl.7: H01Q 1/24, H01Q 1/38, H01Q 9/40, H01Q 23/00, H01Q 1/52

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(71) Applicant: Sony International (Europe) GmbH
10785 Berlin (DE)

(72) Inventor: Brankovic, Veselin,
Advanced Tech. Cr. Stuttgart
Heinrich-Hertz-Strasse, 70327 Stuttgart (DE)

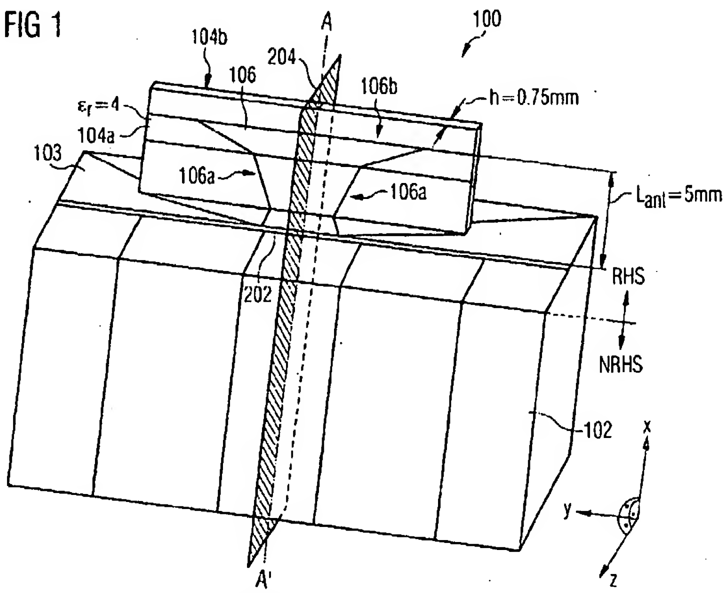
(74) Representative: Rupp, Christian, Dipl.Phys. et al
Mitscherlich & Partner
Patent- und Rechtsanwälte
Sonnenstrasse 33
80331 München (DE)

(54) Low-cost printed omni-directional monopole antenna for ultra-wideband in mobile applications

(57) The underlying invention generally relates to the field of microwave antennas applied to Smart Handheld Devices (SHDs) with high-speed mobile access, and, more particularly, to a new solution for a monopole antenna (106) characterized by an omni-directional radiation pattern (900), in which said monopole antenna (106) is formed by a conductive patch printed on the same substrate (104a) where the RF front-end chip is placed, thereby having the capability of a simple planar feeding, improving cost manufacturing.

Said monopole antenna (106) can advantageously be applied to an antenna system comprising at least one dielectric substrate (104a) with a metallized grounded back plane (104b), one metallic reflector box (102) with at least one metallic reflector plane (103), and at least one microstrip line (105) printed on said dielectric substrate (104a) serving as an electrical feeding from an impedance matching network to the radiation element (106).

FIG 1



RHS: radiating half-space of the monopole antenna 106
NRHS: non-radiating half-space of the front-end chip set

EP 1 324 423 A1

Description

FIELD AND BACKGROUND OF THE INVENTION

[0001] The underlying invention generally relates to the field of microwave antennas applicable for example to Smart Handheld Devices (SHDs) with high-speed mobile access, and, more particularly, to a solution for a monopole antenna having an omni-directional radiation pattern said monopole antenna is formed by a conductive patch printed on the same substrate where the RF front-end chip is placed.

[0002] Nowadays, the growing demand for mobile communications is constantly increasing the need for an enhancement of mobile devices and networks. For instance, Wireless Local Area Network (WLAN) standards in Europe (e.g. HiperLAN/2) and the United States (e.g. IEEE 802.11a) are mainly targeting low-cost types of short-range communication at high data rates. In the future, broadband third and fourth generation cellular systems will be designed to meet QoS requirements of high-performance wireless communication systems in a more cost-effective and flexible manner. In this context, one of the most critical QoS aspects of mobile communications is the choice and deployment of appropriately designed microwave antennas. The rapid growth in civil applications of mobile communications, particularly the increased use of personal mobile terminals, has generated a need for the development of small mobile terminals and small-sized radiating systems. In view of the evolution of said mobile communication systems and progresses in antenna technology, the design concept of microwave antennas has changed as well, although the fundamentals essentially remained the same. Thereby, a careful selection of the antenna, its location, and tuning are the most important factors in ensuring reliable communications.

[0003] Usually, microwave antennas are specified according to a set of parameters comprising operating frequency, gain, Voltage Standing Wave Ratio (VSWR), input impedance and bandwidth. If the VSWR is greater than 3, for instance, a so-called matching network must be placed between the transmitter and its antenna to minimize mismatch loss, although a low VSWR is not a design necessity as long as the antenna is an efficient radiator. Said design is costly and makes an automation of the matching function much slower than designs applying low-power and solid-state tuning elements. In practical applications, the bandwidth of operation is usually prescribed by a governing authority.

[0004] Owing to the mass market introduction of Smart Handheld Devices (SHDs), there is an increasing demand for low-cost microwave antennas today. The mobile wireless communications industry has grown by orders of magnitude, pushed by improvements in digital and RF circuit fabrication, Very Large Scale Integration (VLSI) and antenna miniaturization technologies which make portable wireless equipment small, economical and reliable. In this context, the main issues concerning the design of microwave antennas deployed in the scope of SHDs pertain to the following requirements:

- to have the capability of a simple planar feeding and a printed low-cost manufacturing,
- to achieve a significant cost reduction by simultaneously applying the core substrate of the RF front-end chip as a substrate for the antenna, which means that antenna prints could simultaneously be manufactured by using the layout procedure for classic RF front-end chip circuits,
- to have the capability to cope with omni-directional antenna patterns with gains of 0 to 1 dBi (type 1) and/or sector gains of around 6 dBi (type 2).

[0005] Recently, since emphasis has been laid on reducing size, providing increased power efficiency, and meeting the requirements of the Federal Communications Commission (FCC) for mobile handset emissions, two additional elements of antenna design have risen in importance that must equally be considered along with conventional design parameters: the enhancement of antenna efficiency and the control of the so-called Specific Absorption Rate (SAR).

BRIEF DESCRIPTION OF THE PRESENT STATE OF THE ART

[0006] In order to understand the fundamental idea of the proposed solution according to the underlying invention, it is necessary to briefly describe the concept as well as the main characteristics of microwave antennas, especially broadband microstrip antennas and monopole antennas.

[0007] The basic concept of microstrip antennas was first proposed by Deschamps in 1953. Accordingly, a microstrip antenna in its simplest form consists of a radiating strip conductor patch on top of a thin dielectric substrate or air sheet, and a metallic ground plane on the other side of said substrate. It can be made conformal to a metallic surface and produced at low cost by using photo-etch techniques. When low-profile, lightweight, small-size and low-cost designs are required, microstrip antennas play an important role. The patch or top layer can be of any shape, but conventional

shapes are generally used to simplify analysis and performance prediction. In practical applications, typical shapes of patch radiators are circular and rectangular. Ideally, the permittivity ε_r should be low in order to enhance fringe fields which account for the radiation. However, other performance and design requirements may dictate the use of substrates whose realistic permittivities ε_r may be greater than 5.

[0008] Aside from said advantages, microstrip antennas also involve several drawbacks compared with conventional microwave antennas, e.g. narrow bandwidth (typically in the order of 2 %), a comparatively high dissipation power and therefore a lower gain (about 20 dB), a relatively poor end-fire radiation performance, and the possibility to excite surface waves. Finally, the majority of conventional microwave antennas radiates most of the energy into only a half plane. Various impedance matching networks have been investigated, but the feed network may become quite complex and lossy. It is possible, however, to find remedies against some of these disadvantages by using appropriate designs.

[0009] An example of an antenna exhibiting the radiation characteristics mentioned above without using parasitic reflectors is the Meander Line Antenna (MLA) as disclosed in the US patent 5,790,080,. Said MLA comprises one or more conductive radiation elements and a slow-wave meander line adapted to couple electrical signals between said conductive elements. Thereby, said meander line has an effective electrical length which affects the electrical length and operating characteristics of the MLA. The characteristics of MLAs can be summarized as follows:

- The MLA technology allows engineers to simultaneously design physically small and electrically large antennas which can directly be embedded within a mobile casing. Thereby, MLAs are especially designed for next-generation wireless hardware, including base stations, handsets, laptop computers, Personal Digital Assistants (PDAs), automobiles, and household electronics. By contrast, antennas with a performance that can be compared with that of MLAs are typically much larger and more expensive. With the aid of MLA technology, smaller radiation elements can be combined with a meander line structure and geometry to achieve broadband performance in a small envelope.

[0010] Further printed planar microwave antennas according to the state of the art that apply circular polarization technologies are described in the following patent applications:

[0011] In the European patent application EP 0 795 926, a flat omni-directional antenna is disclosed. According to this approach, a U-shaped bent and stacked reflector slot is applied, in which operation bandwidths are increased with the aid of reflector slots, thereby remaining the size.

[0012] From the European patent application EP 0 818 847, an antenna construction for mobile phones according to the GSM standard is known. It comprises a metallic plane and side walls limiting a box-shaped volume and a resonator element bent over a lateral edge of said plane. Thereby, said resonator element can be kept at a distance by means of a symmetrically arranged short-circuit element and a feeding. The height of said antenna construction is very flat since the distance between the plane and the bent part of the resonator element attached above said plane is smaller than that between the front surface and the L-Shaped bent resonator element. The disclosed antenna has a bandwidth of approximately 20 % and a high efficiency.

[0013] In the US patent 6,259,418, a modified monopole antenna with a compact size for small mobile devices is disclosed which is specially suited for an adaptation to thin profile expansion cards such as the PC standard card as well as other mobile devices with small form factors. This antenna comprises a substantially horizontal ground plane from which a radiator element protrudes which extends upwardly from a central location on the ground plane and bends away from the mobile device. The shape of the radiator element allows the antenna to be retraced into a host device while minimizing the amount of space required to house the antenna in said device. Particular embodiments of the herewith disclosed invention comprise hinging mechanisms to make the antenna more compact and switching mechanisms for an automatic activation of wireless functionality when the antenna is employed.

[0014] In the European patent application EP 1 093 187, a low-profile broadband monopole antenna is disclosed. Said antenna is operable over a predetermined range of frequency, thereby comprising a transmission line, a transformer network connected to one end of the transmission line, and at least one inductor-resistor network connected to an opposite end of said transformer network. Said inductor-resistor network changes the effective electrical length of the antenna in such a way that the current distribution above and below said inductor-resistor network changes with the frequency of operation.

[0015] The US patent 6,188,366 is directed to a monopole antenna system that can be operated at a plurality of frequencies comprising a disk-shaped conductor, a first and a second ring-shaped conductor arranged in that order on the same plane. Thereby, one end of a linear conductor is perpendicularly connected to the center of the disk-shaped conductor, and the outer edge of the disk-shaped conductor is connected to the inner edge of the first ring-shaped conductor via a first anti-resonance circuit. Moreover, the outer edge of the first ring-shaped conductor is connected to the inner edge of the second ring-shaped conductor via a second anti-resonance circuit. Due to said anti-resonance circuits, an electrical blocking is obtained in such a way that electromagnetic waves of three different frequencies can be excited by the system from the linear conductor to the disk-shaped conductor, the first ring-shaped

conductor and the second ring-shaped conductor.

[0016] The US patent 6,181,286 pertains to an integrated dual-mode antenna which can be used as a satellite or terrestrial antenna. It comprises a quadrifilar antenna and a monopole antenna positioned within said quadrifilar antenna, thereby being independent of said quadrifilar antenna. Due to the fact that said monopole antenna has no electromagnetic field in its center, interference or blockage of signals transmitted by the monopole antenna do not occur, thus allowing the antenna to function as if it was completely isolated. This feature facilitates the co-location of said monopole antenna within said quadrifilar antenna without any loss in performance.

[0017] WO 00/76023 relates to a flat-plate monopole antenna comprising a conductive ground plane, a conductive radiating plate, an antenna interface terminal, and a resonant network for defining operating characteristics of said monopole antenna. Thereby, the conductive radiating plate is spaced apart from the ground plane and, together with the ground plane, defines a cavity therebetween. Said antenna interface terminal is in communication with the cavity and is electrically isolated from the ground plane and the radiating plate. The resonant network includes an inductive element electrically coupled between the interface terminal and the radiating plate.

[0018] In the US patent US 6,100,848, a multiple-band printed monopole antenna is disclosed. It comprises a printed circuit board, a monopole radiation element in the form of a conductive trace formed on one side of the printed circuit board. Thereby, said conductive trace has an electrical length that allows a primary resonance in a first specified frequency band, and a parasitic element formed on the opposite side of the printed circuit board designed to tune the conductive trace to a secondary resonance within a second specified frequency band. Although there is no direct electrical connection between the monopole radiation element and the parasitic element, said secondary resonance of the radiation element within the second frequency band is caused by the electromagnetic coupling between these elements.

[0019] None of the prior art documents mentioned above has a capability to be simply printed on the substrate where the RF front-end chip (chip sets) is (are) placed, and simultaneously, to be small and flat enough e.g. for future Personal Digital Assistants (PDAs) and/or "add-in" technologies (PC cards) standardized by the "Personal Computer Memory Card International Association" (PCMCIA).

[0020] Considering the main issues of "Wireless LAN Diversity Antenna System for PCMCIA Card Integration" (IEEE 47th Vehicular Technology Conference, Vol. 3, 1997, pp. 2022-2026) by M. Liebendorfer and U. Dersch, the approach described in EP 0 795 926 consists in that an antenna is placed on the same substrate as the RF front-end chip. Furthermore, this is not a printed antenna. In the approach described in "A Novel Polarization Diversity Antenna for WLAN Applications" (Microwave Conference, Asia-Pacific, 2000, pp. 1518-1521) by Shyh-Tirng Fang, it is proposed to attach antennas to the RF front-end substrate in the same way as proposed in the scope of the underlying invention. However, an integration with said substrate is not possible. In "Wide Band Planar Monopole Antennas" (IEEE Transactions on Antennas and Propagation, Vol.46, February 1998, pp. 294-295) by N.P. Agrawall, G. Kumar and K.P. Ray, different disc types of these structures used as monopoles are analyzed.

DEFICIENCIES AND DISADVANTAGES OF THE KNOWN SOLUTIONS ACCORDING TO THE STATE OF THE ART

[0021] A problem that arises from standard monopole antennas is the dependence on the ground plane as a conjugate radiation element, as well as its small cross-section. The former characteristic has the effect of placing the user in capacitive contact with radiating portions of the antenna system, while the latter provides for high field strengths in close proximity to the antenna, which can produce radiation densities that may exceed government safety limits if adequate spacing or shielding cannot be obtained. The near-field reduction in the above-described MLA is due to its spatially distributed radiating sections serving to form the far-field radiation pattern. At some distance from the antenna, the far-field intensities of both antennas are identical, thereby assuming equal losses.

[0022] Combining spatial distribution methodology of the MLA or other spatially distributed antennas, with the use of fractional wavelength reflectors, such as circuit-board ground planes or shields, can result in additional reduction of near-field intensity in the direction of the user. The same is possible with loop and patch antennas, but efficiency and bandwidth must be considered to obtain the desired level of performance. Directing radiation away from the user can actually be preferable when handset performance is considered, as measurements suggest that 40 % of the RF power from a mobile phone in either the 800-MHz or 1900-MHz band is absorbed by the user's head when an omni-directional antenna is used.

[0023] Directing this energy away from the user allows most of the emitted RF energy to be recovered, which can in some conditions improve the overall average performance. This is particularly true in propagation environments where the signal is subject to multiple reflections, e.g. in dense urban settings. An active power control can reduce the RF power output from the transmitter to a lower level than that achieved with an omni-directional antenna, thereby producing the same received signal level.

OBJECT OF THE UNDERLYING INVENTION

[0024] In view of the explanations mentioned above, it is the object of the invention to propose a simplified low-cost solution for a monopole antenna which can be integrated into a low-cost terminal.

[0025] This object is achieved by means of the features of the independent claims. Advantageous features are defined in the dependent claims.

SUMMARY OF THE INVENTION

[0026] The underlying invention describes a low-cost solution for an antenna structure which allows an integration of the antenna on the same substrate where the RF front-end chip (chip sets) is (are) placed.

BRIEF DESCRIPTION OF THE CLAIMS

[0027] The independent claim 1 and the dependent claims 2 to 4 refer to a planar monopole antenna having an omnidirectional radiation pattern formed by a conductive patch which is used as a radiation element of a mobile computing and/or communication device and/or a base station for the transmission and/or reception of microwaves within a predetermined bandwidth of operation, characterized in that

- said dielectric substrate is inserted into a slot in the reflector plane of said metallic reflector box, thereby perpendicularly protruding out of said reflector plane,
- the grounded back plane of the dielectric substrate is electrically connected with said reflector box at a first edge of said slot,
- there is a gap between a second edge of said slot opposite to the electrically connected first edge of said slot and the microstrip line at the contact area between said microstrip line and said radiation element, and/or
- the dielectric substrate, the reflector box, the radiation element and the microstrip line of said antenna system are symmetrically shaped with regard to a cutting plane going through the center of the microstrip line perpendicular to the plane of the dielectric substrate and the reflector plane.

[0028] In addition, the independent claim 5 and the dependent claim 6 relate to an antenna system of a mobile computing and/or communication device and/or a base station used for the transmission and/or reception of microwaves within a predetermined bandwidth of operation, in which at least two planar monopole antennas having omnidirectional radiation patterns, each formed by a conductive patch used as a radiation element are applied.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] Further advantages and possible applications of the underlying invention result from the subordinate claims as well as from the following description of one embodiment of the invention as depicted in the following drawings. Herein,

Fig. 1 shows a 3D front view of the proposed radiation element formed by a planar monopole antenna printed on a dielectric substrate which is passed through a slot in the reflector plane on top of a metallic reflector box,

Fig. 2 shows a 3D view exhibiting the feeding microstrip line of the proposed radiation element and the dielectric substrate inserted into a reflector slot in the reflector plane of said reflector box,

Fig. 3 shows a sectional 3D view of the metallic reflector box and the reflector slot, thereby applying the symmetry of the monopole antenna to a vertical cutting plane through the center of the microstrip line and the monopole antenna parallel to the x- and z- axis,

Fig. 4 depicts the frequency characteristic of a simulated scattering parameter S_{11} for structures comprising a metallic reflector box with a finite size, in which S_{11} is less than -10 dB for HiperLAN/2 applications, and a minimum of approximately -20 dBi is obtained at approximately 5.35 GHz,

Fig. 5 exhibits the radiation pattern of said monopole antenna in case of an open reflector box with a finite size at

5 GHz, in which the maximum gain G_{max} of approximately +1.5 dBi is obtained at an azimuthal angle Φ of approximately ± 60°,

Fig. 6 depicts the frequency characteristic of the simulated scattering parameter S_{11} for structures comprising a metallic reflector box with a finite (electrically small) size as depicted in Fig. 1, in which a minimum of approximately -17.0 dBi is obtained at approximately 5.3 GHz,

Fig. 7 exhibits the radiation pattern of said monopole antenna in case of an open reflector box with a finite small size at 5.5 GHz, in which a maximum gain G_{max} of approximately 0.28 dBi is obtained at an azimuthal angle Φ of ± 60°,

Fig. 8 shows an omni-directional radiation pattern obtained at 5.5 GHz and at an elevation angle Θ of 90°,

Fig. 9 outlines a simulation for one embodiment of the proposed monopole antenna with a very small reflector box having a size of approximately 5 × 5 × 1 cm^3,

Fig. 10 exhibits a simulated omni-directional radiation pattern of said monopole antenna for the reflector box as depicted in Fig. 9, and

Fig. 11 depicts the frequency characteristic of a simulated scattering parameter S_{11} according to the proposed embodiment of the underlying invention, in which a singularity is obtained at approximately 5.3 GHz, simulated for structures comprising a small reflector box with a finite size without any optimization to specific requirements.

DETAILED DESCRIPTION OF THE UNDERLYING INVENTION

[0030] In the following, one embodiment of the underlying invention as depicted in Figs. 1 to 11 shall be explained in detail. The meaning of the symbols designated with reference signs in Figs. 1 to 11 can be taken from the appended Table 3.

[0031] Fig. 1 depicts a radiation element for RF signals used in the scope of a mobile terminal which is formed by a printed planar monopole antenna 106 according to the proposed solution of the underlying invention. The features of said monopole antenna 106 can be summarized as follows:

- The monopole antenna 106 is printed on a dielectric substrate 104a, which is preferably the same substrate 104a on which the RF front-end of the mobile terminal is placed.
- The electrical feeding of the monopole antenna 106 is provided by a microstrip line 105 as depicted in Fig. 1. In contrast to conventional antenna technologies according to the state of the art, special mounting pins are not needed for said feeding.
- The dielectric substrate 104a on which the monopole antenna 106 is printed is passed through a metallic reflector box 102 from the inner side where the RF front-end is placed to the outer side where the radiation is performed. Fig. 2 shows a 3D view 200 exhibiting the feeding microstrip line 105 of the proposed radiation element 106 and the dielectric substrate 104a inserted into a reflector slot 202 on the reflector plane 103 of said reflector box 102.
- The grounded back plane 104b of the dielectric substrate 104a is connected to the reflector plane 103, in which the dielectric substrate 104a is passed from the radiating half-space (RHS) where the RF front-end is placed to the non-radiating half-space (NRHS) where the monopole antenna 106 is placed.
- The dielectric substrate 104a on which said monopole antenna 106 is printed is inserted into a slot 202 in the reflector plane 103 on top of the metallic reflector box 102. In this context, it should be noted that there is no electrical connection between the metallic reflector box 102 and the metallized parts of the feeding microstrip line 105 (printed on the dielectric substrate 104a) protruding into the radiating half-space (RHS). On the contrary, there is a clear gap 203 between them which has to be optimized from case to case. For this reason, a compromise has to be made as follows: On the one hand, said gap 203 has to be as large as possible in order to avoid the introduction of a discontinuity to the printed metal microstrip line 105. On the other hand, the large gap 203 may impair the characteristics of the metallic reflector box 102. For this reason, the radiation power can be radiated from the so-called radiating half-space (RHS) where the radiation element 106 is placed to the non-radiating half-space (NRHS)

where the RF front-end is placed. Fig. 3 exhibits a sectional 3D view 300 of the metallic reflector box 102 and the reflector slot 202 (the gap 203 between said reflector box 102 and the metallic stripe forming a monopole antenna 106 printed on said substrate 104a), thereby applying the symmetry of the monopole antenna 106 to a vertical cutting plane 204 through the center of the microstrip line 105 and the monopole antenna 106 parallel to the x- and z-axis. It can be observed that the feeding network (in the non-radiating half-space, NRHS) consists of a microstrip line 105 which comprises a grounded metallization area 104b attached to the rear side of the printed dielectric substrate 104a. It can be observed that the edges of said metallization area closely approach the reflector box 102. At the edge of this metallization area, said dielectric substrate 104a and said reflector box 102 are electrically connected.

- Although the width (h) of the dielectric substrate 104a may possibly vary, it does not significantly influence the radiation characteristics. However, it should be noted that in the example depicted in Fig. 3 the width (h) of the dielectric substrate 104a at the level of the reflector plane 103 is reduced.

- The proposed antenna solution refers to a monopole antenna 106 with a special shape and a special feeding.

- The shape of the monopole antenna 106 is characterized in that the metallic print - the printed surface of the dielectric substrate 104a in the radiating upper half-space (RHS) above the reflector plane 103 - comprises two symmetrical lateral edges 106a with regard to the cutting plane 204. The form of these lateral edges 106a is prescribed by the radiation element 106 which begins at the point where the dielectric substrate 104a protrudes into the radiating half-space (RHS), and ends at an upper edge 106b parallel to the reflector plane 103.

- The shape of said lateral edges 106a as well as the total length of the lateral edges 106a and the upper edge 106b are main factors for the performance design of said printed planar monopole antenna 106. In the context of the proposed solution according to the underlying invention, said lateral edges 106a are characterized by convex shapes. In this context, the term "convex shape" means that if two points on each lateral edge 106a were connected by a virtual connection line, said line would be a secant or a tangent of the curved or polygonal lateral edge 106a, in which said line would be placed beyond the metallic surface of the radiation element 106 or directly on its lateral edge 106a, respectively.

- Special embodiments using more than one radiation element 106 printed on the same dielectric substrate 104a where the RF front-end is placed, thereby having the same characteristics as described above, are also disclosed in the scope of the underlying invention. This is especially true for the case of simple diversity antennas with typically two radiation elements 106 as described above.

[0032] The concept of the monopole antenna 106 as described above can be verified with the aid of a simulation using a specific 3D antenna software. Thereby, the finite dimensions of the reflection plane 103, as well as metallic reflector boxes 102 can be considered.

[0033] The following table shows a data set for the simulation in case of a metallic reflector box 102 with a finite size:

Parameter	Variable	Value
Thickness of the Dielectric Substrate 104a (= the thickness of the monopole antenna 106)	h	0.75 mm
Thickness of the Feeding Microstrip Line 105	W_{line}	2.6 mm
Height of the Monopole Antenna 106 (= height of the metallic monopole portion 106 printed on the dielectric substrate 104a), thereby taking the metal reflector box 102 as a reference	L_{ant}	5 mm
Antenna Length (= the maximum length distance between the metallic prints)	W_{ant}	12 mm
Permittivity of the Dielectric Substrate 104a (low-cost material, usually applied to RF front-end assemblies)	ε_r	4

[0034] In this context, it should be noted that the wall thickness of the metallic reflector box 102 is assumed to be zero, as well as losses in dielectric substrate 104a.

[0035] In the scope of the underlying invention, simple reflector boxes 102 with a finite size of $100 \times 200\ mm^2$ as well as metallic reflector boxes 102 having a size of $50 \times 50 \times 10\ mm^3$ up to a very small size of $20 \times 20 \times 10\ mm^3$ are used for simulations. Thereby, it may be observed that the operation bandwidth tends to be smaller when a smaller

reflection box 102 is applied.

[0036] Some simulation results and simulated structures are presented in Figs. 4 to 11. For example, Fig. 4 depicts the frequency characteristic of a simulated scattering parameter S_{11} for structures comprising a metallic reflector box 102 with a finite size, in which S_{11} is less than -10 dB for applications on the basis of HiperLAN/2. Fig. 5 depicts the radiation characteristics of said monopole antenna 106 in case of an open reflector box 102 with a finite size at 5 GHz, in which the maximum gain G_{max} of approximately +1.5 dBi is obtained at an azimuthal angle Φ of approximately $\pm$ 60°. Thereby, it can be observed that the maximum gain is theoretically around 1.5 dBi at 60° elevation.

[0037] Next, Fig. 6 shows the frequency characteristic of the simulated scattering parameter S_{11} for structures comprising a metallic reflector box 102 with a finite small size as depicted in Fig. 1, in which a minimum of approximately -17.0 dBi is obtained at approximately 5.3 GHz. The radiation characteristics of said monopole antenna 106 in case of an open reflector box 102 with a small size at 5.5 GHz can be taken from Fig. 7, in which the maximum gain G_{max} of approximately 0.28 dBi is obtained at an azimuthal angle Φ of $\pm$ 60°.

[0038] Moreover, Fig. 8 shows an omni-directional antenna pattern at an elevation angle Θ of 90°.

[0039] In Fig. 9, 10 and 11, special embodiments of the proposed monopole antenna 106 with a small reflector box 102 are depicted. Thereby, Fig. 9 shows a simulation for one embodiment of the proposed monopole antenna 106 with a very small reflector box 102 having a size of approximately $5 \times 5 \times 1$ cm^3. Moreover, Fig. 10 exhibits the simulated radiation characteristics of said monopole antenna 106 for the reflector box 102 depicted in Fig. 9 which can be observed when an omni-directional diagram is obtained. Due to the simplified simulation model and the small sizes of the reflector box 102 and its reflector slot 202 at the bottom part of said reflector box 102, some back plane peaks may occur. Finally, Fig. 11 depicts the frequency characteristic of a simulated scattering parameter S_{11} according to the proposed embodiment of the underlying invention, in which a singularity is obtained at approximately 5.3 GHz, simulated for structures comprising a small reflector box 102 with a finite size without any optimization to specific requirements.

[0040] In the following sections, a method for supporting and optimizing wireless communication systems using integrated antennas 106 as proposed in the scope of the underlying invention shall briefly be described:

a) Optimization of the height (L_{ant}) of the monopole antenna 106 and the length (W_{ant}) of the microstrip line 105: The main resonance of the monopole antenna 106 depends on its total edge length. This means that the desired resonance can be found by increasing the length of the metallic monopole portion 106 printed on the dielectric substrate 104a (L_{ant}) and decreasing the the maximum length distance between the metallic prints (W_{ant}) and vice versa. By carefully optimizing these parameters, the ideal size and shape of the monopole antenna 106 can be realized according to the respective application and product specification. However, the radiation patterns may vary, thereby yielding peak radiation at different elevation levels.

b) Optimization of the size and shape of the metallic reflector box 102: The dimensions of the metallic reflector box 102 also influence the resonance position and the radiation characteristics of the monopole antenna 106. Therefore, the following design procedure for a predetermined operation frequency is recommended:

1. defining the thickness (h) and permittivity (ε_r) of the dielectric substrate 104a on which the RF front-end (chip) assembly is placed,

2. designing the shape of the final product for particular applications (e.g. PC cards according to the PCMCIA standard, access points, etc.), thereby considering the actual size of the potential metallic surface to be used as a reflector box 102,

3. defining the underlying application scenario and approximating the targeted radiation diagram,

4. using start parameter values for the height (L_{ant}) of the proposed monopole antenna 106 and the length (W_{ant}) of the microstrip line 105 and for a finite large-size reflector box 102, then optimizing the parameters of said monopole antenna 106 by using at least two points connected by a virtual connection line on a lateral edge 106a of said monopole antenna 106 for an optimization. In this context, it should be noted that in case of a simulation only two points are used for an optimization of the lateral edge 106a in the scope of the underlying invention.

[0041] Moreover, it should be noted that in case other dielectric substrates 108 (with $\varepsilon_r \neq 4$) and/or other frequencies of operation are used, the start parameter values may be scaled linearly (up or down) by applying the following rule: If an unscaled linear size L_1 is given at a frequency f_1 for a permittivity ε_{r1}, a scaled new starting value L_2 for an optimized size can be provided by means of the following equation, thereby yielding a very rough estimation that may be sufficient for determining the starting values for a detailed antenna optimization:

$$L_2 = L_1 \cdot \frac{f_1}{f_2} \cdot \sqrt{\frac{\varepsilon_{r1}}{\varepsilon_{r2}}}$$

with

ε_{r1}: old permittivity value,
ε_{r2}: new permittivity value,
f_1: old frequency of operation value,
f_2: new frequency of operation value,
L_1: unscaled (old) linear size (height and/or length) of the monopole antenna 106 or the metallic reflector box 102, and
L_2: scaled (new) linear size (height and/or length) of the monopole antenna 106 or the metallic reflector box 102.

[0042] From the results of the simulations as depicted in Figs. 4 to 8, 10 and 11, it can be concluded that the proposed concept may be applied to applications in the 5-6 GHz range, specially for applications based on the IEEE 802.11a or HiperLAN/2 standard. However, a careful optimization of the antenna parameters has to be performed, thereby taking into account the specific application scenario, the targeted radiation pattern, the applied dielectric substrate 104a, and the actual size limitations of the mobile device in which the monopole antenna 106 is integrated. Said simulation results confirm that an omni-directional antenna pattern having a maximum gain of 0 to 2 dBi in the elevation of 40° to 60° by remaining a VSWR smaller than 2 is achievable in a specific frequency range of interest. It can be stated that the proposed concept is quite simple and can be realized with less cost compared with the solutions according to the cited state of the art. Moreover, the total size of the radiation element 106 is smaller than the size of comparable radiation elements according to the state of the art.

Table 1:

Glossary	
Term	**Brief Explanation**
Access Point (AP) Antenna	An omni-directional antenna or multiple panel (directional) antennas mounted on a tall tower or building.
Antenna Directivity	The ratio of the maximum radiation intensity to the average radiation intensity (averaged over a sphere). It is a measure of how focused an antenna coverage pattern is in a given direction. A theoretical loss-less antenna element, referred to as a isotropic element, has 0 dBi directive gain equally distributed in all three dimensions. In orderto achieve a higher directive gain, antennas are normally designed to focus or concentrate the antenna pattern only in the direction of the radio link, thereby maximizing energy usage. The directivity of any source, other than isotropic, is always greater than unity.
Antenna Efficiency	A parameter which is used to compare basic antenna radiation elements. It is a measure of how much of the electrical power supplied to an antenna element is converted to electromagnetic power. A hundred per cent efficient antenna would theoretically convert all input power into radiated power, with no loss to resistive or dielectric elements. Thereby, the total antenna efficiency accounts for the following losses: - reflection due to mismatches between the feeding transmission line and the antenna, and - antenna conductor and dielectric losses.

Table 1: (continued)

Glossary	
Term	Brief Explanation
Antenna Gain	The product of the directivity and the efficiency of an antenna. This parameter is used to compare different antenna radiation characteristics. Unlike directivity, it takes into account both the directive property of the antenna, as well as how efficiently it transforms available input power into radiated power. If the efficiency is not 100 %, the gain is less than the directivity. When the reference is a lossless isotropic antenna, the gain is expressed in dBi (decibels as referenced to an isotropic antenna element). An isotropic antenna is a theoretical point source radiating equal power in all directions, resulting in a perfect spherical pattern. This ideal reference point is defined as 0 dBi. When the reference is a half-wave dipole antenna, the gain is expressed in dBd (decibels as referenced to a dipole antenna element). Thereby, 0 dBd corresponds to 2.15 dBi.
Antenna Pattern	A graphical representation for the radiation of an antenna as a function of the azimuthal angle and/or elevation angle. Antenna radiation performance is usually measured and recorded in two orthogonal principal planes (e.g. E-Plane and H-plane or vertical and horizontal planes). The pattern is usually plotted either in polar or rectangular coordinates. The pattern of most WLAN antennas contains a main lobe and several minor lobes, termed side lobes. A side lobe occurring in space in the direction opposite to the main lobe is called back lobe.
Chu-Harrington Limit	A theoretical limit (curve) relating the volumetric size of an antenna element to its quality or bandwidth of operation. For antenna design, this relationship gives the designer an estimate of a tradeoff between size and desired bandwidth. For example, the Meander Line Antenna (MLA) is very close to the Chu-Harrington limit, while a standard half-wave dipole is not.
Customer Premises (CPE) Antenna	Usually a small directional antenna which points to an access point (AP).
Directional Antenna	An antenna having the property of radiating or receiving electromagnetic waves more effectively in some directions than in others. A directional antenna is usually defined as uni-directional and not omni-directional.
Effective Radiated Power (ERP)	In a given direction, the relative gain of a transmitting antenna with respect to the maximum directivity of a half-wave dipole multiplied by the net power accepted by the antenna from the connected transmitter. By contrast, EIRP is the effective radiated power with respect to the directivity of an isotropic radiator.
Frequency Bandwidth	The range of frequencies within which the performance of the antenna, with respect to some characteristics, conforms to a specified standard. In this context, the VSWR of an antenna is the main bandwidth-limiting factor.
Gain Pattern	Normalizing the power/field to that of a reference antenna yields a gain pattern. When the reference is an isotropic antenna, the gain is expressed in dBi. When the reference is a half-wave dipole in free space, the gain is expressed in dBd.
Half-Wave Dipole	A wire antenna consisting of two straight collinear conductors of equal length, separated by a small feeding gap, with each conductor approximately a quarter-wavelength long.
Isotropic Radiator	A hypothetical, lossless antenna having equal radiation intensity in all directions. For a WLAN antenna, the gain in dBi is referenced to that of an isotropic antenna (which is defined as 0 dBi).

Table 1: (continued)

Glossary	
Term	Brief Explanation
Linear Array	A set of radiation elements (e.g. dipoles or patches) arranged along a line with dimensions comparable to a wavelength. A linear array has a higher gain than a single radiator, and its radiation pattern can be synthesized to meet various antenna performance requirements such as upper side lobe suppression. It should be noted that the gain of any antenna is proportional to its size.
Meander Line Antenna (MLA)	A new type of three-dimensional radiation element, made from a patented combination of a loop antenna and frequency-tuning meander lines. This structure results in an antenna element that is more efficient than currently used antenna elements in wireless applications. An example are MLAs by SkyCross. These antennas are physically very small, while being electrically very large.
Microstrip Antenna	An antenna which consists of a thin metallic conductor bonded to a thin grounded dielectric substrate. An example of such antenna is the microstrip patch.
Normalized Pattern	Normalizing the power/field with respect to its maximum value yields a normalized power/field pattern with a maximum value of unity (or 0 dB).
Omni-directional Antenna	An antenna having an essentially non-directional pattern in a given plane of the antenna and a directional pattern in any orthogonal plane. For WLAN antennas, the omni-directional plane is the horizontal plane spanned by the x- and y-axis.
Radiation Efficiency	The ratio of the total power radiated by an antenna to the net power accepted by the antenna from the connected transmitter.
Return Loss	The difference between the power input to and the power reflected from a discontinuity in a transmission circuit. This parameter is often expressed as the ratio in decibels of the power incident on an antenna terminal to the power reflected from the terminal at a particular frequency or in a band of frequencies.
Specific Absorption Rate (SAR)	A measure that estimates the amount of radio frequency power absorbed in a unit mass of body tissue over time. In the interest of ensuring public and user safety, the Federal Communications Commission (FCC) and other regulatory bodies have developed safety standards for radio frequency emissions of mobile phones. Accordingly, all cellular phones manufactured after August 1, 1996 must be tested against these FCC guidelines for safe exposure. For example, the limit for SAR in the United States is 1.6 mW/g.
Voltage Standing Wave Ratio (VSWR)	The ratio of the maximum/minimum values of a standing wave pattern along a transmission line to which a load is connected. VSWR value ranges from 1 (matched load) to infinity for a short or an open load. For most WLAN antennas, the maximum acceptable value of VSWR is 2.0. VSWR values of 1.5 or less are excellent. A VSWR of 2.0 (or a return loss of 9.5 dB) means that 90 % of the signal from the transmitter to the antenna is radiated, and 10 % is reflected.

Table 2:

Depicted Features and their Corresponding Reference Signs	
No.	Feature
100	3D front view of the proposed radiation element 106 formed by conductive patch serving as a planar monopole antenna printed on a dielectric substrate 104 that is passed through a slot 202 in the reflector plane 103 on top of a metallic reflector box 102
102	metallic reflector box with a finite (electrically small) size which serves as a casing for the monopole antenna 106
103	reflector plane of said reflector box 102
104a	dielectric substrate which can be inserted into a reflector slot 202 of said reflector box 102
104b	grounded back plane of said dielectric substrate 104a
105	microstrip line printed on said dielectric substrate 104a which serves as an electrical feeding line from an impedance matching network to the monopole antenna 106
106	radiation element (planar monopole antenna) having an omni-directional radiation pattern formed by a conductive patch printed on said dielectric substrate 104
106a	lateral edge of said radiation element 106
106b	upper edge of said radiation element 106
200	3D view showing the feeding microstrip line 105 of the proposed radiation element 106 and the dielectric substrate 104 inserted into a slot 202 in the reflector plane 103 of said reflector box 102
202	reflector slot (the gap between said reflector box 102 and the metallic stripe forming a monopole antenna 106 printed on top of said substrate 104)
203	gap between a second edge of said slot 202 opposite to the electrically connected first edge of said slot 202 and the microstrip line 105 at the contact area between said microstrip line 105 and said radiation element 106
204	vertical cutting plane through the center of the microstrip line 105 and the monopole antenna 106 parallel to the x- and z-axis providing a longitudinal section of said microstrip line 105 and said monopole antenna 106
300	sectional 3D view of the metallic reflector box 102 and the reflector slot 202, thereby applying the symmetry of the monopole antenna 106 to said cutting plane 204
400	frequency characteristic of a simulated scattering parameter S_{11} for structures comprising a metallic reflector box 102 with a finite size, in which S_{11} is less than -10 dB for HyperLAN/2 applications, and a minimum of approximately -20 dBi is obtained at approximately 5.35 GHz
600	radiation characteristics of said monopole antenna 106 in case of an open reflector box 102 with a finite size at 5 GHz, in which the maximum gain G_{max} of approximately +1.5 dBi is obtained at an azimuthal angle Φ of approximately $\pm$ 60°
700	frequency characteristic of the simulated scattering parameter S_{11} for structures comprising a metallic reflector box 102 with a finite (electrically small) size as shown in Fig. 1, in which a minimum of approximately -17.0 dBi is obtained at approximately 5.3 GHz
800	radiation characteristics of said monopole antenna 106 in case of an open reflector box 102 with a finite small size at 5.5 GHz, in which the maximum gain G_{max} of approximately 0.28 dBi is obtained at an azimuthal angle Φ of $\pm$ 60°
900	omni-directional radiation pattern obtained at 5.5 GHz and at an elevation angle Θ of 90°
1000	simulation for one embodiment of the proposed monopole antenna 106 with a very small reflector box 102 having a size of approximately $5 \times 5 \times 1$ cm^3
1100	simulated omni-directional radiation pattern of said monopole antenna 106 for the reflector box 102 as depicted in Fig. 10

Table 2: (continued)

Depicted Features and their Corresponding Reference Signs	
No.	Feature
1200	frequency characteristic of a simulated scattering parameter S_{11} according to the proposed embodiment of the underlying invention, in which a singularity is obtained at approximately 5.3 GHz, simulated for structures comprising a small reflector box 102 with a finite size without any optimization to specific requirements

Claims

1. A planar monopole antenna having an omni-directional radiation pattern formed by a conductive patch which is used as a radiation element (106) comprising:

    - at least one dielectric substrate (104a) with a metallized grounded back plane (104b),
    - one metallic reflector box (102) serving as a casing for said dielectric substrate (104a) which comprises at least one metallic reflector plane (103), and
    - at least one microstrip line (105) printed on said dielectric substrate (104a) which serves as an electrical feeding from an impedance matching network to said radiation element (106),

    characterized in that

    - said dielectric substrate (104a) is inserted into a slot (202) in the reflector plane (103) of said metallic reflector box (102), thereby perpendicularly protruding out of said reflector plane (103),
    - the grounded back plane (104b) of the dielectric substrate (104a) is electrically connected to said reflector box (102) at a first edge of said slot (202),
    - a gap (203) is provided between a second edge of said slot (202) opposite to the electrically connected first edge of said slot (202) and the microstrip line (105) at the contact area between said microstrip line (105) and said radiation element (106), and
    - the dielectric substrate (104a), the reflector box (102), the radiation element (106) and the microstrip line (105) of said antenna system are symmetrically shaped with regard to a cutting plane (204) going through the center of the microstrip line (105) perpendicular to the plane of the dielectric substrate (104a) and the reflector plane (103).

2. A planar monopole antenna according to claim 1,
characterized in that
said monopole antenna (106) is printed on the same dielectric substrate (104a) on which the RF front-end chip (chip sets) is (are) placed.

3. A planar monopole antenna according to claim 2,
characterized in that
the lateral edges (106a) of the printed monopole antenna (106) have a convex shape.

4. A planar monopole antenna according to anyone of the claims 2 and 3,
characterized in that
a virtual connection line parallel to the reflector plane (103) connecting two points on the two lateral edges (106a) of said monopole antenna (106) steadily increases towards the upper edge (106b) of said monopole antenna (106).

5. An antenna system for a mobile computing and/or communication device and/or a base station used for the transmission and/or reception of microwaves within a predetermined bandwidth of operation, comprising:

    - at least two planar monopole antennas (106) having omni-directional radiation patterns, each formed by a conductive patch which is used as a radiation element (106),
    - at least one dielectric substrate (104a) with a metallized grounded back plane (104b),
    - one metallic reflector box (102) serving as a casing for said dielectric substrate (104a) which comprises at least one metallic reflector plane (103), and

- at least two microstrip line (105) printed on said dielectric substrate (104a) which serve as an electrical feeding from an impedance matching network to said radiation elements (106),

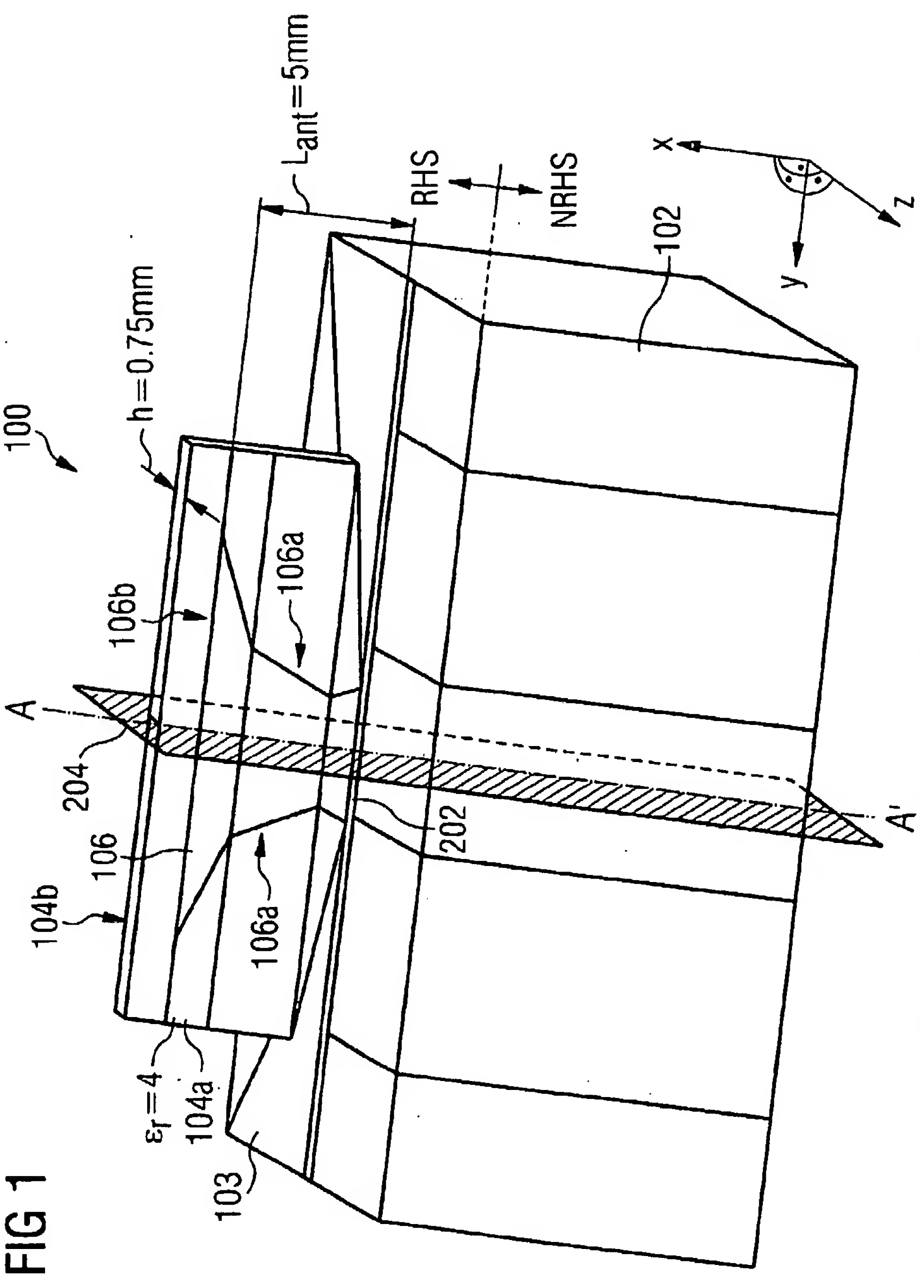
characterized in that

- said dielectric substrate (104a) is inserted into a slot (202) in the reflector plane (103) of said metallic reflector box (102), thereby perpendicularly protruding out of said reflector plane (103),
- the grounded back plane (104b) of the dielectric substrate (104a) is electrically connected with said reflector box (102) at a first edge of said slot (202),
- a gap (203)is provided between a second edge of said slot (202) opposite to the electrically connected first edge of said slot (202) and the microstrip lines (105) at the contact areas between said microstrip lines (105) and said radiation elements (106), and
- the dielectric substrate (104a), the reflector box (102), the radiation elements (106) and the microstrip lines (105) of said antenna system are symmetrically shaped with regard to a cutting plane (204) going through the center of the microstrip lines (105) perpendicular to the plane of the dielectric substrate (104a) and the reflector plane (103).

6. An antenna system according to claim 5,
characterized in that
said monopole antennas (106) are printed on the same dielectric substrate (104a) on which the RF front-end chip (chip sets) is (are) placed.

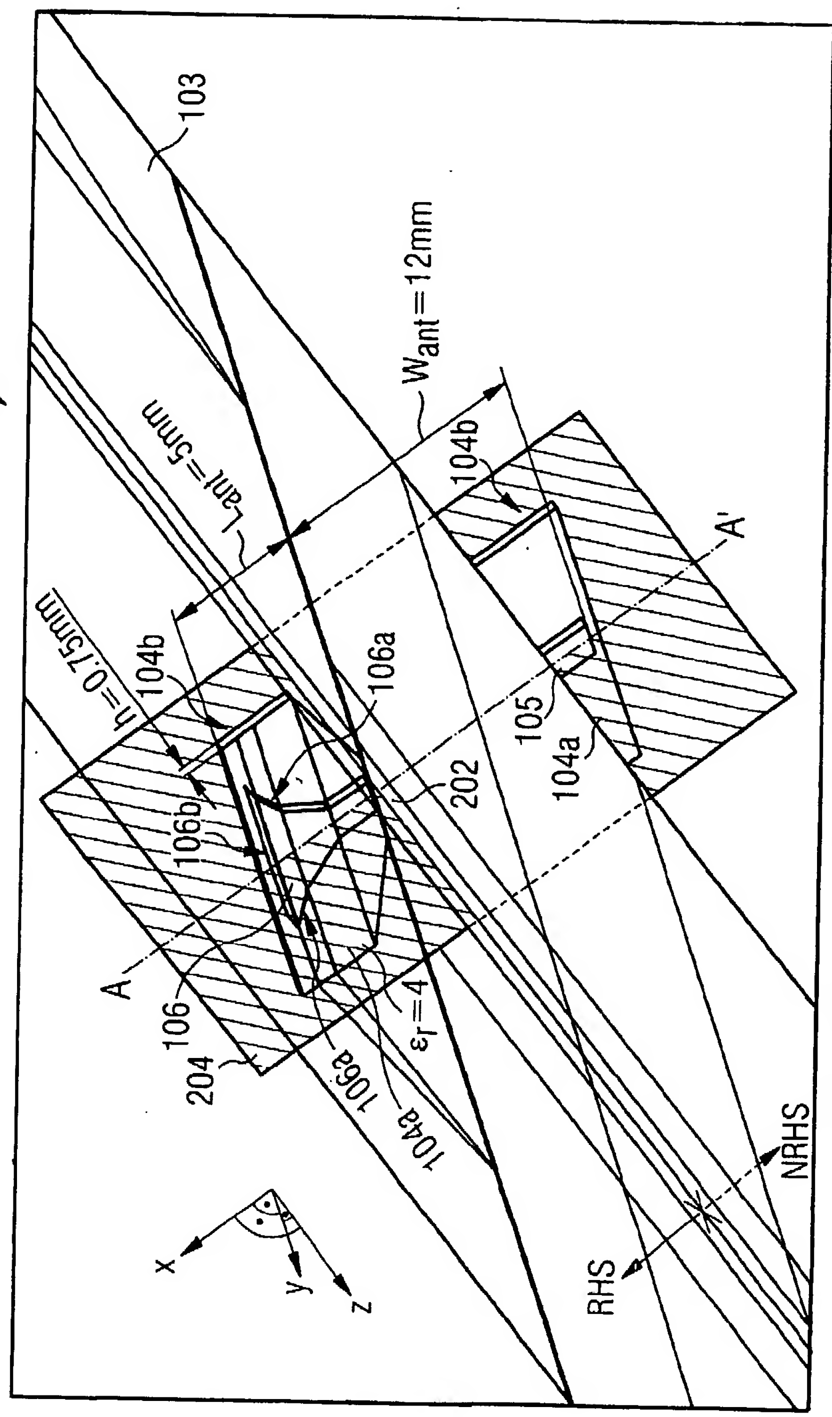
7. A mobile telecommunications device,
characterized by
at least one monopole antenna (106) according to anyone of the claims 1 to 4 or an antenna system according to anyone of the claims 5 and 6.

FIG 1



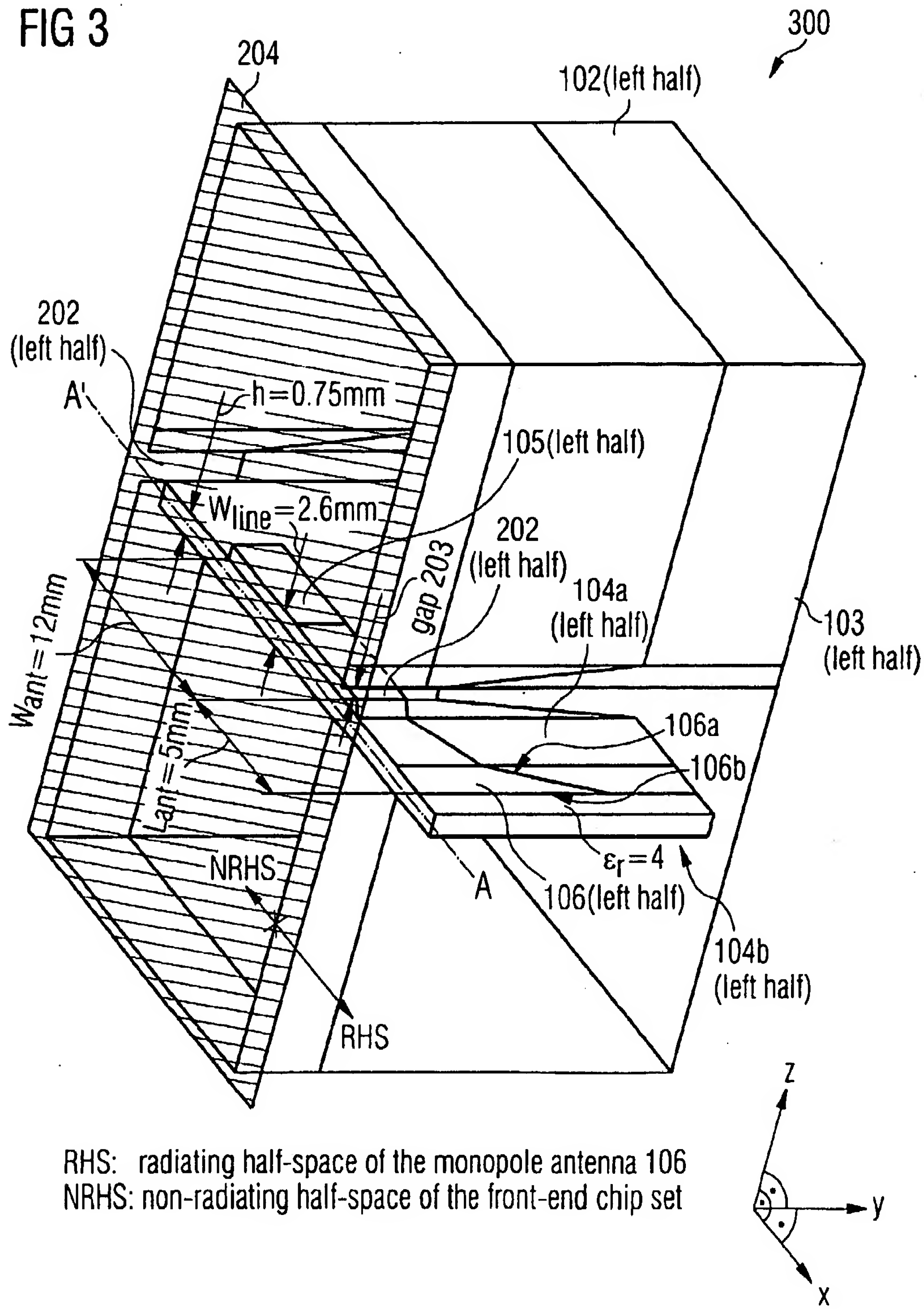
RHS: radiating half-space of the monopole antenna 106
NRHS: non-radiating half-space of the front-end chip set

FIG 2



RHS: radiating half-space of the monopole antenna 106
NRHS: non-radiating half-space of the front-end chip set

FIG 3



RHS: radiating half-space of the monopole antenna 106
NRHS: non-radiating half-space of the front-end chip set

FIG 4

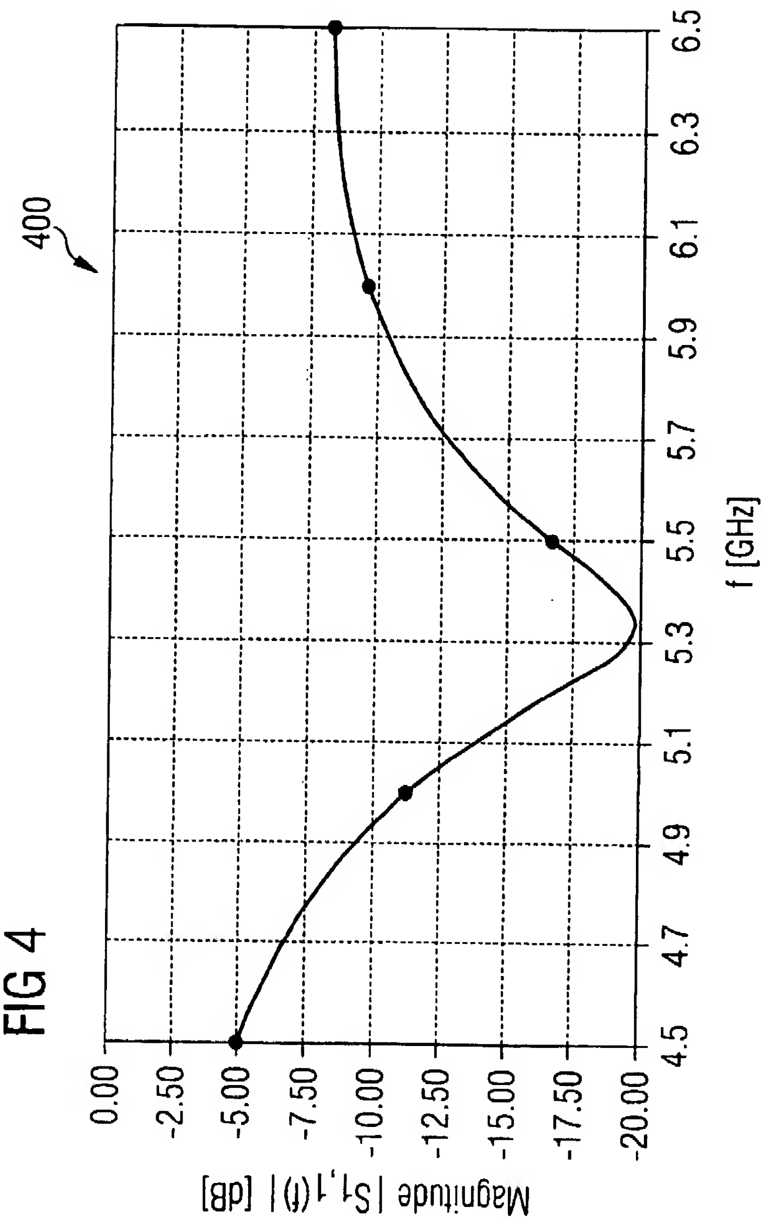

400
Magnitude |S1,1(f)| [dB]
0.00
-2.50
-5.00
-7.50
-10.00
-12.50
-15.00
-17.50
-20.00
4.5
4.7
4.9
5.1
5.3
5.5
5.7
5.9
6.1
6.3
6.5
f [GHz]

FIG 5

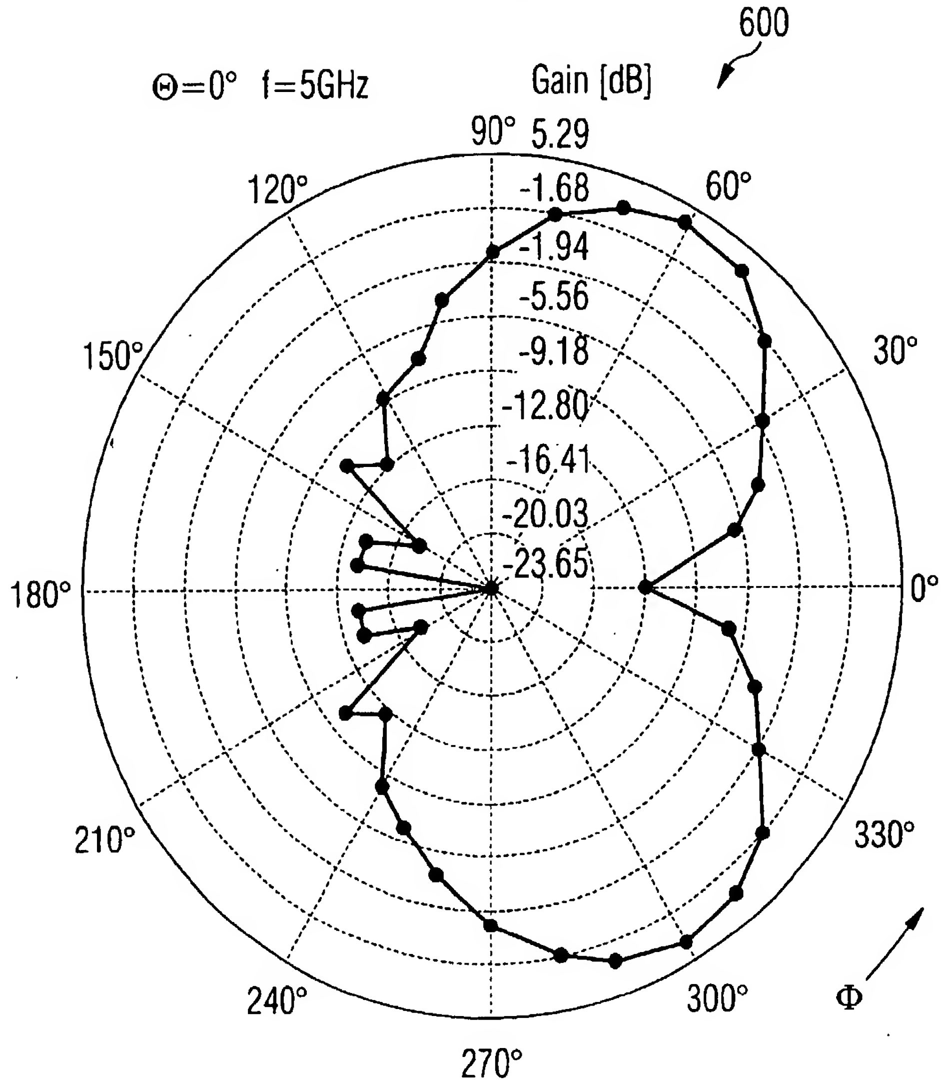

600
Θ=0° f=5GHz
Gain [dB]
90° 5.29
-1.68
-1.94
-5.56
-9.18
-12.80
-16.41
-20.03
-23.65
120°
60°
150°
30°
180°
0°
210°
330°
240°
300°
270°
Φ

FIG 6

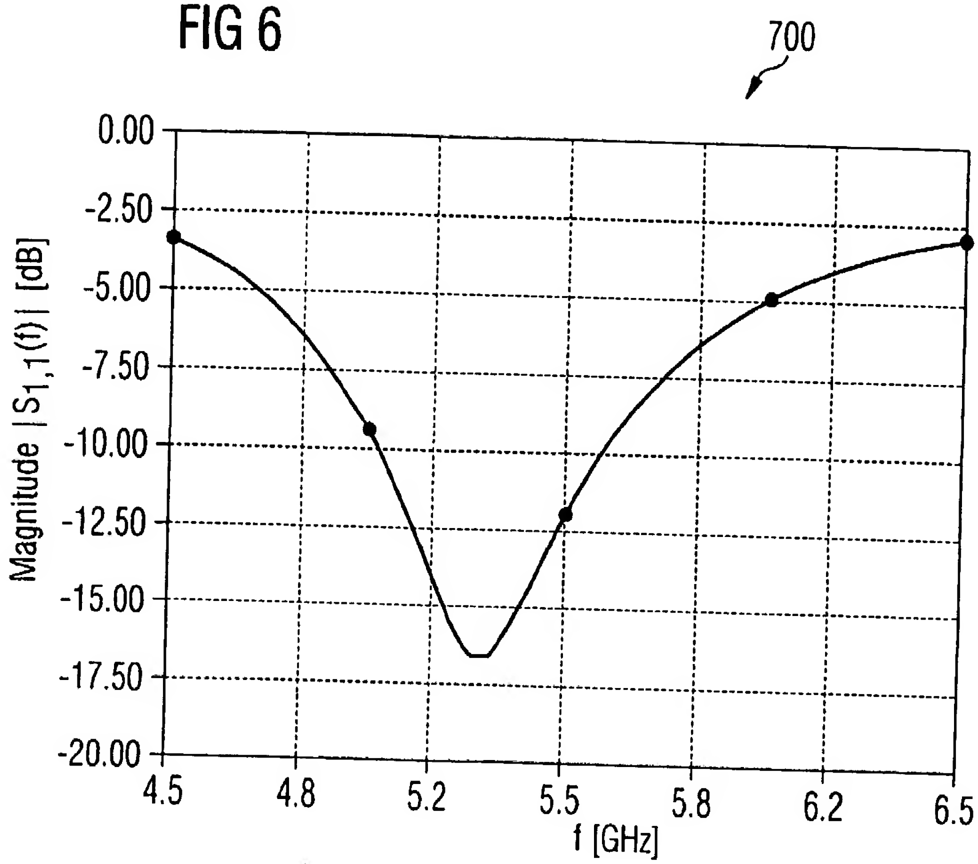

700
0.00
-2.50
-5.00
-7.50
-10.00
-12.50
-15.00
-17.50
-20.00
Magnitude | $S_{1,1}(f)$ | [dB]
4.5
4.8
5.2
5.5
5.8
6.2
6.5
f [GHz]

FIG 7

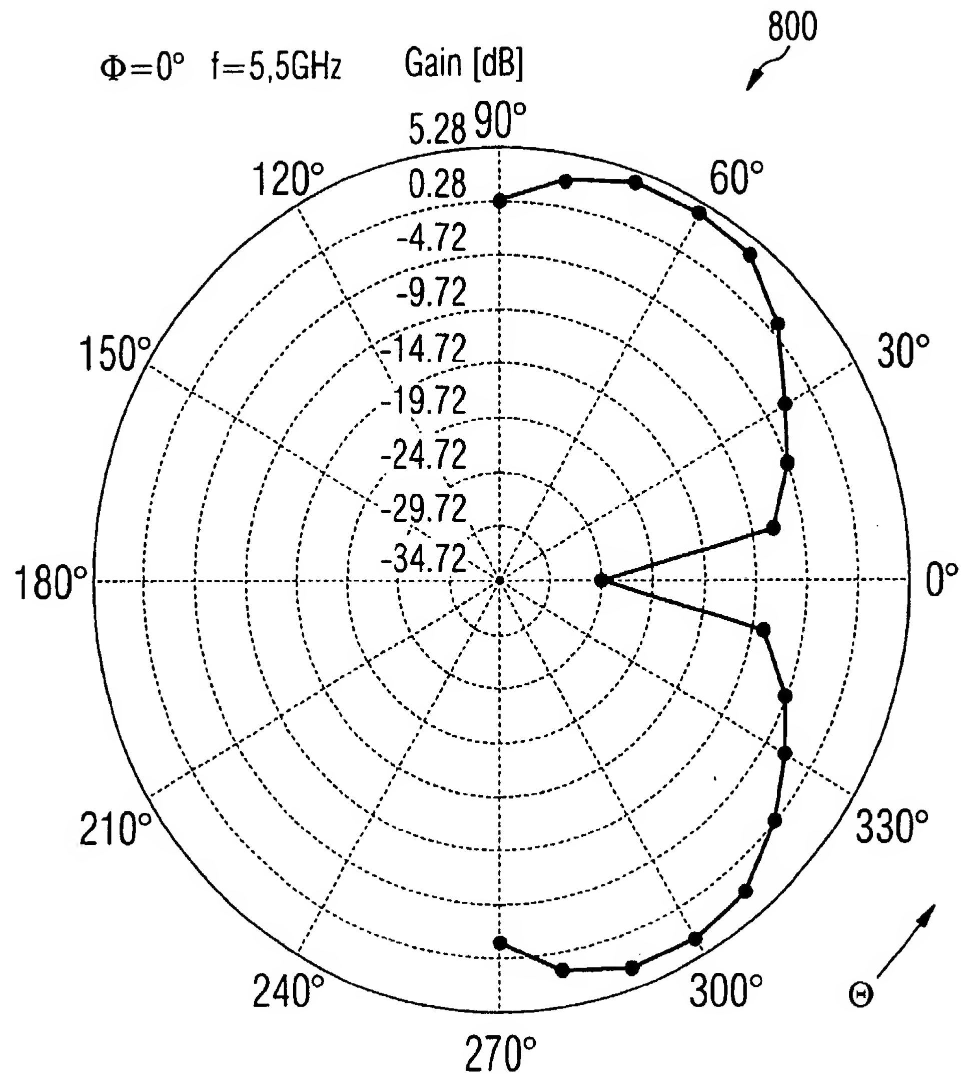

800
Φ=0° f=5,5GHz
Gain [dB]
5.28
0.28
-4.72
-9.72
-14.72
-19.72
-24.72
-29.72
-34.72
90°
60°
30°
0°
330°
300°
270°
240°
210°
180°
150°
120°
Θ

FIG 8

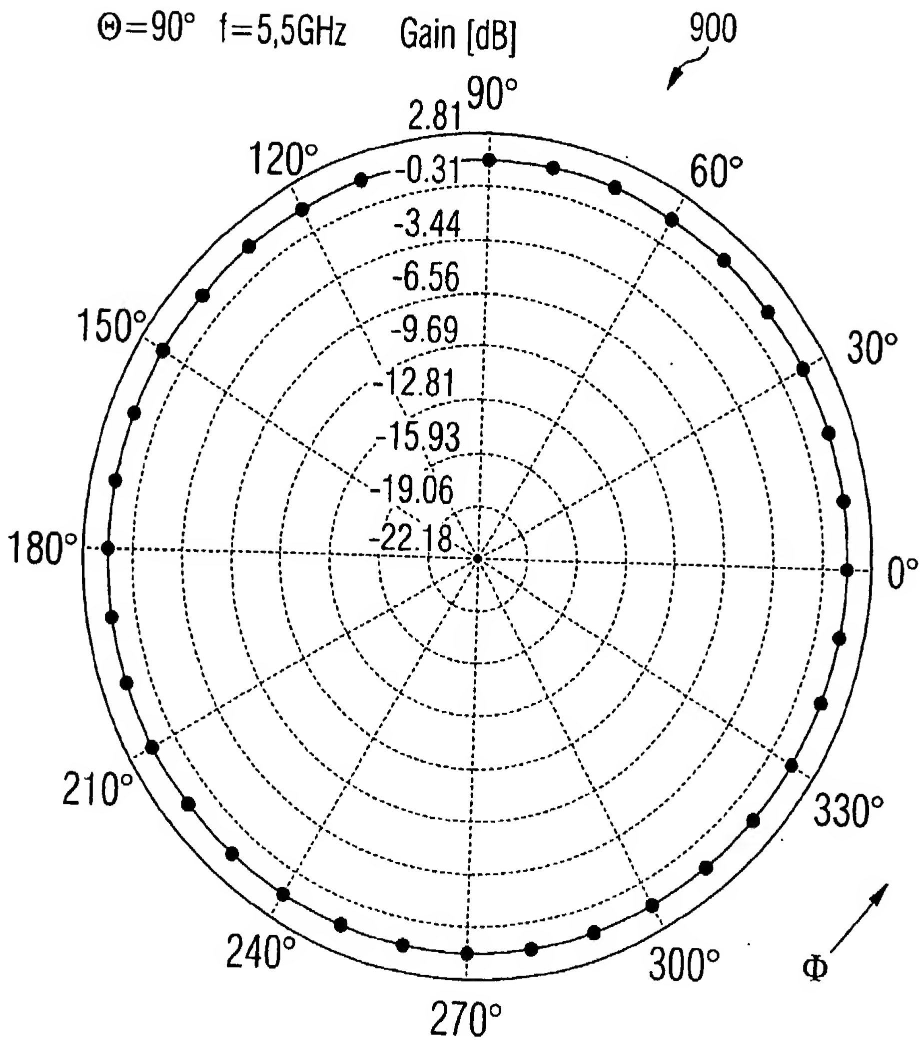
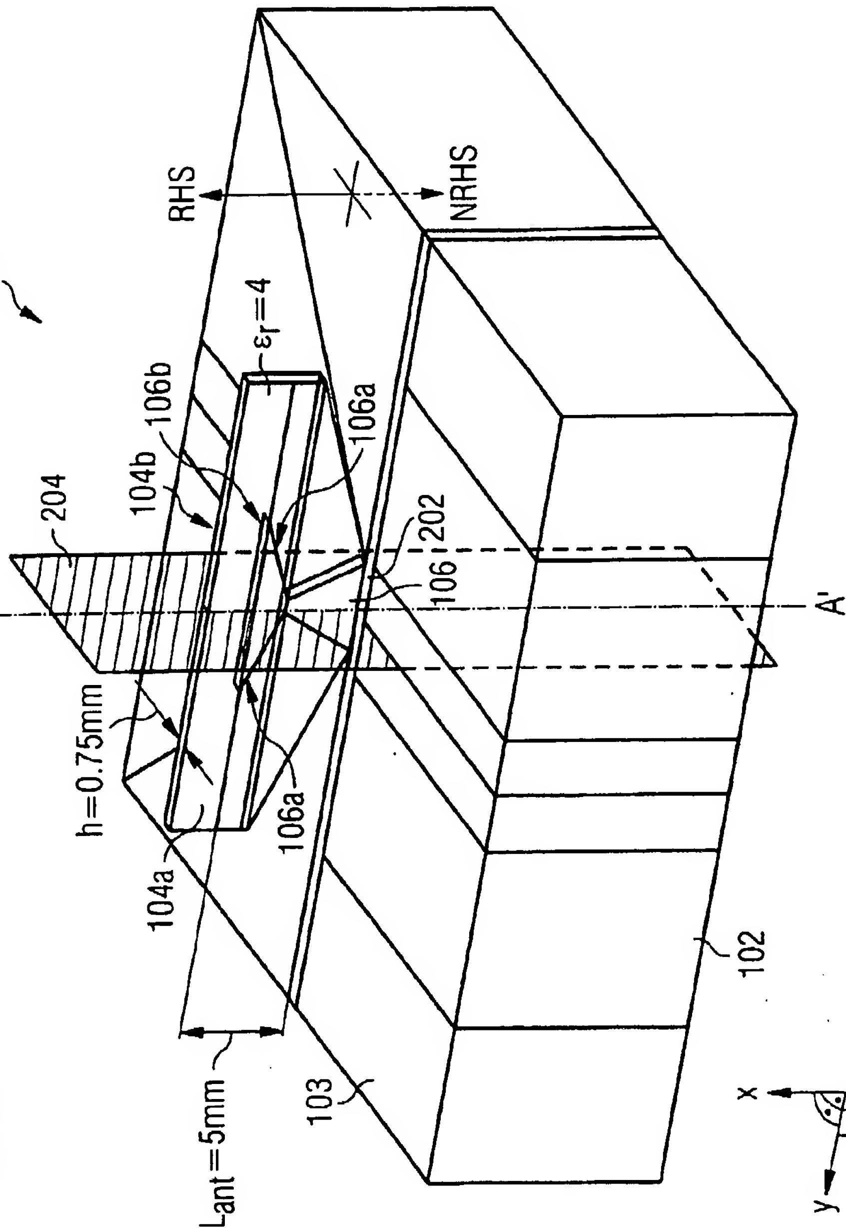

Θ=90° f=5,5GHz Gain [dB]
900
90°
60°
30°
0°
330°
300°
270°
240°
210°
180°
150°
120°
2.81
-0.31
-3.44
-6.56
-9.69
-12.81
-15.93
-19.06
-22.18
Φ

FIG 9



RHS: radiating half-space of the monopole antenna 106
NRHS: non-radiating half-space of the front-end chip set

FIG 10

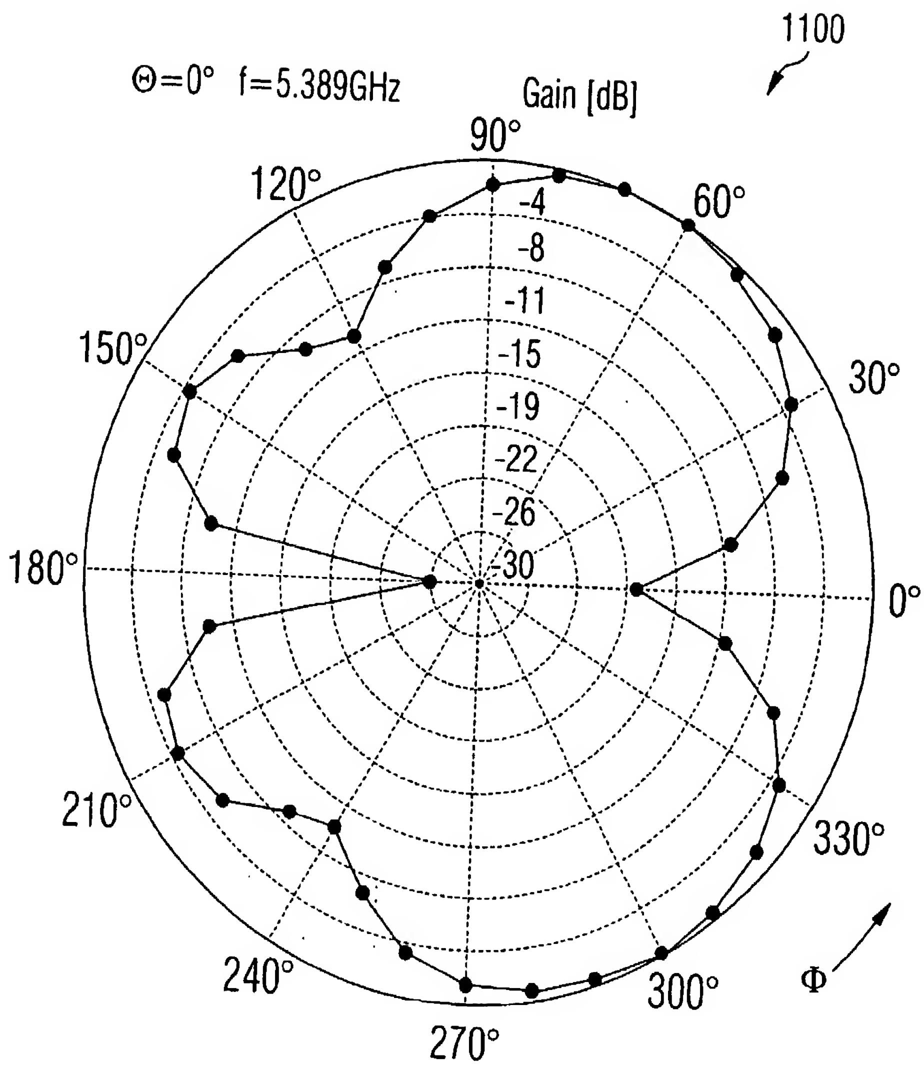
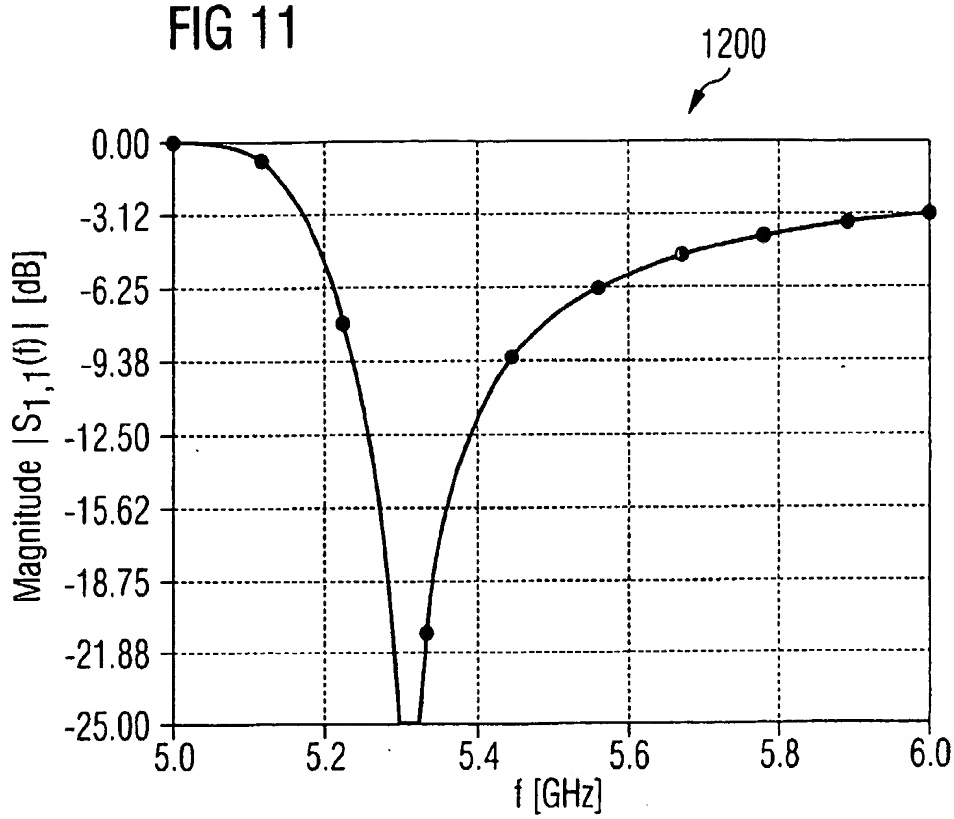

1100
Θ=0° f=5.389GHz
Gain [dB]
90°
120°
60°
150°
30°
180°
0°
210°
330°
240°
300°
270°
Φ
-4
-8
-11
-15
-19
-22
-26
-30

FIG 11


1200
0.00
-3.12
-6.25
-9.38
-12.50
-15.62
-18.75
-21.88
-25.00
Magnitude |S1,1(f)| [dB]
5.0
5.2
5.4
5.6
5.8
6.0
f [GHz]

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 13 0864

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	DE 196 47 648 A (IND TECH RES INST) 28 May 1998 (1998-05-28) * abstract; figures 5A-5C,6A-6D * * column 1, line 19-25 * * column 3, line 30-55 * * column 4, line 27,28,51-60 * * column 5, line 36 - column 6, line 30 * * column 7, line 7-62 * ---	1-7	H01Q1/24 H01Q1/38 H01Q9/40 H01Q23/00 H01Q1/52
A	EP 0 522 538 A (NIPPON ELECTRIC CO) 13 January 1993 (1993-01-13) * column 3, line 10-30; figure 2 * ---	2	
A	US 5 828 340 A (JOHNSON J MICHAEL) 27 October 1998 (1998-10-27) * abstract; figure 1 * * column 2, line 13-49 * ---	1,5	
A	EP 1 113 524 A (NOKIA MOBILE PHONES LTD) 4 July 2001 (2001-07-04) * abstract; figures 9-12 * * column 13, line 32-47 * -----	5	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	10 June 2002	Cordeiro, J-P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 01 13 0864

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

10-06-2002

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
DE 19647648	A	28-05-1998	DE	19647648	A1	28-05-1998
EP 0522538	A	13-01-1993	JP	2887956	B2	10-05-1999
			JP	5022184	A	29-01-1993
			AU	654017	B2	20-10-1994
			AU	1960392	A	14-01-1993
			CA	2070894	A1	12-01-1993
			DE	69222366	D1	30-10-1997
			DE	69222366	T2	09-04-1998
			EP	0522538	A2	13-01-1993
			US	5392461	A	21-02-1995
US 5828340	A	27-10-1998	NONE			
EP 1113524	A	04-07-2001	FI	20001023	A	01-07-2001
			EP	1113524	A2	04-07-2001
			US	2001007445	A1	12-07-2001

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

THIS PAGE BLANK (USPTO)